numerical target zone 62 automatically.

[0255] At step S18 (step S16 will be described later), after extracting the data of the numerical target zone, the extracted data is standardized. Figs. 6A and 6B are magnified SEM images of predetermined upper and lower portions of the numerical target zone 62 shown in Fig. 5, respectively. If the two magnified images shown in Figs. 6A and 6B are numerated, the distribution of an image data value is significantly changed according to brightness and contrast, as shown in Figs. 7A and 7B. Figs. 7A and 7B are views of magnitude distributions when the image data values are divided into five grades by changing the image data value from 0 to 250. If the image having a low brightness shown in Fig. 6A is numerated, there exists many data values of 150 or less. By contrast, if the image having a high brightness shown in Fig. 6B is numerated, there exist many data values of 150 or more. In such a state, it is difficult to objectively determine the growth degree of the HSGs. Therefore, it is advantageous to determine the growth degree of the HSGs by standardizing respective image data values of pixels disposed within the numerical target zone 62, using a maximum value and a minimum value of the image data thereof.

[0260] The standardization with respect to the image data of respective pixels disposed within the numerical target zone 62 is performed using the following equation:

$$NC_{ij} = \left(\frac{C_{ij} - C_{\min}}{C_{\max} - C_{\max}} \right) \times K \qquad \text{(Eq. 1)}$$

where, NC_{ij} is a standardized image data value of a pixel disposed at a point (i,j), C_{ij} a non-standardized image data value of the pixel disposed at the point (i,j), $C_{\min}$ is a minimum value of image data within the numerical target zone, $C_{\max}$ is a

maximum value of image data within the numerical target zone, and K is a constant. It is desirable that the constant K is set to the number of total gradations of the monitor. For example, if the number of the gradations of the monitor is 256, the constant K is also set to 256.

[0265] If all the pixel data of the pixels disposed within the numerical target zone 62 are standardized using Equation 1, the standardized data value NC_{ij} has a value between 0 and K. Figs. 8A and 8B are views of SEM images obtained after standardizing the SEM image shown in Figs. 6A and 6B, respectively. Referring to Figs. 8A and 8B, it can be seen that numerated brightness grades are distributed much more uniformly.

[0270] Meanwhile, prior to the standardization process, it is preferable to first perform a smoothing process (step 16) with respect to the image data of the respective pixels. Although the smoothing process is not always required, it is desirable in order to obtain a more accurate numerical calculation result. Recall that the standardization is performed using the maximum value and the minimum value of the pixel data within the numerical target zone. When the maximum value and the minimum value are determined, if a digitalization noise component is contained in the image, the possibility of error increases due to the influence of the noise on the maximum value and the minimum value. This problem can be solved using the smoothing process for minimizing the noise component contained in the image data of the respective pixels.

[0275] The smoothing process changes the image data of the respective pixels disposed within the numerical target zone using an average value of the image data of adjacent pixels. One smoothing method is performed using the following equation:

$$AC_{ij} = \frac{\sum_{k=0,l=0}^{k=2,l=2} C_{i+j,j+k}}{9} \qquad \text{(Eq. 2)}$$

where, AC_{ij} is an average image data value of a pixel disposed at a point (i,j), and $C_{i+j,\,j+k}$ are non-standardized image data values of the adjacent pixels. Using the above-mentioned smoothing equation, the image data of 8 adjacent pixels and the average value of their own image data are calculated. Then, the previous image data of the pixels to be smoothed are replaced with the calculated average value. The smoothing process is applied to all the pixels disposed within the numerical target zone 62 to complete the smoothing process. Note that the number of the pixels contained when the average value of the image data is calculated need not always be 9. If the pixels to be smoothed can be removed, it is possible to calculate the average value of only several pixels, e.g., 4 pixels, among the 8 adjacent pixels.

[0289] At step S20, the standardized image data values of the respective pixels are compared with a predetermined threshold value. Then the number of pixels is counted for which the standardized image data value is greater than the threshold value.

[0285] Finally, at step S22, the growth degree of grains on the surface of the numerical target zone is determined or numerated by calculating the ratio of the number of the counted pixels with respect to a number of total pixels disposed within the numerical target zone.

[0290] Referring now to the second algorithm of Fig. 4, the difference with the algorithm of Fig. 3 is that the operator selects the numerical target zone in Fig. 4, rather than it being automatically selected. Certain of the steps in both algorithms are the same, so a further detailed discussion of those steps will be skipped where